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UNIVERSAL ATTRACTION

AND

ITS RELATION TO THE CHEMICAL ELEMENTS.

THE KEY TO A CONSISTENT PHILOSOPHY.

W. H. SHARP.

1884

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Phys 370.5

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UNIVERSAL ATTRACTION

ITS RELATION TO THE CHEMICAL ELEMENTS

THE KEY TO A CONSISTENT PHILOSOPHY

BY

W. H. SHARP

Nature and Nature's laws lay hid in night:
God said Let Newton be! and all was light.

POPE.

Except perhaps the *dark* lines in its spectrum!

W. H. S.

C.

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PREFACE.

If Nature had told Newton as much as she has since told those who regard him as her infallible interpreter, he would, I believe, have declared even more forcibly than he did that her first law is order.

It is about 200 years since his "Principia" appeared, and chemistry and electricity have since then as sciences been born into the world.

Newton was concerned with the study of material bodies and their attractive force—gravitation. Chemistry is concerned with the minute atoms into which those material bodies are supposed to be capable of being divided, and their attractive force—affinity.

I shall try to explain what the distinction is between these forces, but in the meantime let me say that, though we might have expected Nature's law of attraction would be universal in its principle, Newton's law of so-called universal attraction is not universal in principle, inasmuch as it requires to be replaced or supplemented by other laws devised to suit the phenomena of sciences not known in his time. And although chemistry and physical science declare the beautiful order of all the arrangements they make of the elementary atoms, yet, strange as it may appear, gravitation, chemistry, and the physical sciences all purchase their order at the terrible cost of assuming elementary disorder as regards the atoms which Nature gives them to work with. Philosophers innumerable

have speculated upon these atoms and the ties that bind them together. A right understanding of them is of vital importance to every science, and therefore indirectly affects the welfare of all humanity.

We are told at this present time that the atoms used by Nature are of about 65 different kinds, and that if they are of equal weights they are of the oddest sizes, and if, as is generally assumed, of equal sizes, Nature has made them of the oddest possible weights. Using one mould for all she is supposed to have compressed 16 units of matter into it to make the oxygen atom, 197 into it for the platinum atom, 19 for fluorine, 118 for tin, 207 for lead, only 1 for hydrogen, $87\frac{1}{2}$ for strontium, $27\frac{3}{5}$ for aluminium, and $39\frac{1}{10}$ for potassium, and so on; and as these have not been subdivided, they are labelled as if to warn us not to look inside—*Atoms*, which means, as you know, indivisible portions of matter.

I am confident it is a libel upon Nature to say she made such condensed masses, if for no other reason than that she would have conducted the compression with more rhyme or reason if there had been any such compression required, which, it appears to me, there was not.

With the reader's permission I shall try to show these supposed atomic aggregates in a better light.

The points I intend to bring before you are these :—

1. That gravitation being measured by mass, mass measured by weight, and weight dependent upon first knowing the values of mass and gravitation, we presently argue of them in a circle, so far as the law of gravitation itself is concerned.

2. That mass is the most important term in the equation of Newton's law, and that chemistry suggests a value for it which enables us to limit the operation of that law to its own proper province, and unite affinity and gravitation by

means of a higher all-comprehensive law founded upon the principles of universal sympathy and selective absorption.

3. That gravitation is propagated by wave motion, and that the earth has a gravitic field of force differing from that of a magnet chiefly in regard to the heterogeneity of the included waves.

4. That the atomic weights are expressions of the relation of regular periodic rates of motion of atomic masses to the resultant rate of motion of earth's constituents.

5. That there is no more necessity for separate laws of gravity and affinity than there is for separate laws to account for the forces exercised by a magnet, first, in attracting a body from a distance, and secondly, in retaining the body once they are in contact.

6. That the condensed atom is a logical absurdity, and that not only does the earth move, but its component atoms also move, and their rates of motion are in all probability infinitely more significant than its motion as a whole.

I might say what I have to say in fewer words were I addressing only those who are conversant with universal science. On the other hand I might extend these pages almost indefinitely were I to attempt to describe or even suggest all the details which have led me to the conclusions I respectfully lay before you, or the countless deductions that they give rise to. I am deeply conscious of the infinite importance of the task essayed, and my utter inability to do it justice. I fully realise the inconveniences which must attach to departure from the beaten track, and that the inertia of scientific opinion is not to be easily, if at all, overcome by anything I or anyone else can say, so long as it may seem to imply anything anti-Newtonian.

Newton undoubtedly deserves the gratitude and respect of

all men for his carefully conducted experiments and able mathematical analysis, which have enabled us to attain to most marvellous accuracy with regard to the motions of the heavenly bodies. I entertain the most profound respect for him, although as will be seen by the following pages it is in my opinion necessary to draw a line somewhere, and I would draw it where respect merges into abject homage, and belief in his having been inspired 200 years ago to write as it were upon tables of stone a law, which was to be a complete and sufficient revelation regarding the estimation of matter, and universal attractive force for all time.

As it will be objected, and rightly so, that my theory is to some extent based upon assumption, I shall before commencing upon it call your attention to the fact that the law I discuss is based upon some of the most remarkable assumptions that ever were made. Still I am aware that in a scientific sense it might for long have been truly said, and never perhaps more truly than at present—

"Whom the gods wish to destroy they first make"—

to doubt the infallibility of Newton.

The spectroscope has shown us there is more in light than Newton knew of, even though light be synonymous with Newton, and I try to show there may be more in gravitation than was dreamt of in his philosophy.

If annihilation be the penalty of my temerity, I am happy to know that no one else will be even remotely involved in its consequences.

If scientific progress always depends upon blind unquestioning acceptance of that which is supposed to be beyond question, if it depends upon lazily committing oneself to be carried forward with the swift current of prejudice

and received opinion, I shall leave that progress to others. In attempting to swim against that stream I essay the harder task, and trust that since I do so not out of obstinacy or bravado, but in search of truth, I may receive for my intentions' sake that patient consideration of my suggestions which their style scarcely deserves, but which the results they lead up to, will in the future assuredly *compel.*

I seek not to end the law of our scientific Moses, but rather to show that though presently bound up with the interests of its prophets it may possibly be replaced by a higher all-embracing dispensation suited to the necessities of the Gentile sciences.

Addressing myself firstly to the favoured nation of physical science, I assume a mutual knowledge of physical and chemical facts up to the present time, and the first demand will naturally be a sign—an experiment. Signs innumerable have already been given. Presently I rely upon (1) the signs we have in the law itself of its own incompleteness; (2) the signs recorded in the literature of science.

Those who refer to Galileo's experiment and say what I suggest assumes the opposite result, which it does not, may admit the assumption to be infinitely more reasonable than the assumptions (1) of perpetual rectilinear motion of actual matter; (2) of the existence of space unoccupied by a resisting medium; and (3) of the uniformity of the earth's action upon equal masses of matter without regard to their chemical differences and atomic motions, all which, with others, underlie the Newtonian laws of motion and his law of gravitation which I am to discuss.

Did anyone ever see or know to exist otherwise than as a mental abstraction, space unoccupied by matter in its ordinary sense, or ether, a term used for matter in its extraordinary

sense, viz., that which leaves it open to be conjured with as either matter or motion at the pleasure of those who use it? If there was nothing—no ether—in the space through which the celestial bodies appear to move, how could Newton ever have known of their existence? If ether is not matter of exceeding tenuity and mobility, how can it be shown to be mere motion which implies change of position of matter, and which, if matter is not, has itself no existence?

Now we are certified that every particle in motion would continue to move perpetually onward in a straight line unless compelled by impressed forces to depart from that line. But we do not exist in mental abstraction surrounded by space wherein is nothing; we exist in a universe, a space real, which appears filled even to its most distant and infinitesimal subdivisions with *something*, and in that universe celestial and other bodies all move. Newton's assumption amounts apparently to this: If the concrete were moving in the abstract, perpetual motion would result if no force interfered. I do not know that; but if Newton says so, we have, some may think, no alternative but to believe it.

But taking Newton's statement as a kinematic proposition relating to abstract matter, motion, and space, and admitting it to be true, it is expedient, before applying the deductions from it to their supposed concrete equivalents in the form of a dynamic proposition, that we carefully examine the factors, check their co-efficients, and know their values and the effect of difference of conditions, before we proceed to use them in our calculations. This hitherto has not been done, and above all, I submit it has not been recognised that entirely different conditions exist in actual space to those which suffice at present for the abstract conception of it.

The first law of motion considered as a basis of dynamics

amounts apparently to this. If a material particle were moving uniformly in space which has no existence save as a mental abstraction, *i.e.*, empty space, and under conditions which are absolutely impossible of attainment to begin with, that which is every day said to be physically impossible would result, viz., perpetual motion—along an infinite straight line, provided that did not happen which physically we say cannot but happen so long as another particle exists in the universe.

We apply these conclusions based upon the absolutely impossible and infinite which we do not know, as an infallible limit to the knowledge of the possible finite which we do or may know, and with as much apparent reason as we might allow ourselves to be limited in the study of actual conic sections, by an assumption that in space of fifteen dimensions an ellipse might turn out to be an oblique prism, a proposition which it would be worse than futile to discuss.

So much for the first of Newton's assumptions, but how is it his laws have answered so well? It will be asked—Has not their application lead to the prediction of the existence of a planet which was afterwards discovered, and to thousands of other predictions not less exact? Certainly, and Newton has not been sufficiently praised for his labours; still other systems existed before his that were considered perfect in their time, and yet which were successively replaced by others, as men's minds were opened more to the necessities of Nature; and I ask if it becomes us at the close of the nineteenth century to say that, while some tell us we know not yet what matter is, and others doubt whether it even exists at all, the law of Newton, who knew much less of Nature than we know, is to limit and control men's minds for ever?

I know it is more easy to take that which appears the winning side. I am not so destitute of worldly wisdom as not to see that it would be easier to follow the multitude in believing the verbal inspiration of the "Principia," and assist in the massacre of all unbelievers, or those who cannot admit Nature to be synonymous with Newton.

I have not the least wish to dogmatise, and the singular pronoun is only used herein because the plural might appear to compromise more than myself.

I submit herein the rough outline of views resulting from twenty years' investigation of the sciences referred to, perfectly aware that there exist some whose intuitive knowledge of the limits of the possible and the finite will enable them to dismiss it without examination in so many minutes as an evidence of unaccountable weakness, and as an attempt to use in vindication of the unity and harmony of Nature, *assumption*, to which, disguised under more pretentious titles, Newton is held to have established an exclusive proprietary right absolutely irrefragible now and for all time.

These pages are written in no spirit of hostility either to Newton or those whose minds are fascinated by his power. I simply speak as a junior counsel on the side of Nature to oppose further extension of Newton's patent, *if and only so far* as it can be shown to involve injustice to Nature, and to be injurious to the interests of scientific progress.

Those who assume the infallibility of Newton is an all-sufficient answer to this and similar productions will please consider me as in no way addressing them. None could be more willing than I to leave unruffled the calm serenity of their convictions. To such I would gracefully return the pity they would extend me, with the assurance that I do so not as unappreciative of their kindness, but as recognising

their greater need to retain that which may prove useful to them by-and-bye, and the intrinsic value of which is so great that it would, while not enriching me, leave them poor indeed.

Those, on the other hand, who without any love of change for its own sake, and without any desire to encourage innovation, shall approach the enquiry unprejudiced and unbiased, whatever their decision may be, may rely upon my respecting their opinions whether adverse or otherwise. Where they are unable to agree upon a verdict after first allowing due weight to the evidence of facts and properly interpreted results of experiments, they will be guided so far as positive evidence is wanting by the balance of reasonable probability. I shall claim the exercise of a "benevolent neutrality" on behalf of Nature, and where nothing remains but an equality of probabilities I shall scarcely need to remind them that, in accordance with the true spirit of scientific procedure, Nature is entitled to the benefit of the doubt; and if Newton were here I am persuaded none would be more ready than he to concede it.

UNIVERSAL ATTRACTION.

THOUGH the greatest philosophers have been, and are uncertain what matter is, yet if there is one thing in this world that is considered more certain than all else, and is every day acted upon as being unquestionably correct, it is probably the comparison of the relative amounts of matter by by what is termed "weight." If one were to suppose there were different amounts of matter in a pound of iron and a pound of lead, the supposition would be laughed to scorn, on the ground that whatever property of matter may be made a fair subject of discussion, weight is utterly beyond all question, and to the results of its determination every other measurement of matter must be held subordinate. This having been accepted as true from the earliest ages in the everyday concerns of life, received if possible additional confirmation as the result of Newton's researches into the earth's attractive force, whereon that which we usually term "weight" depends. His deservedly celebrated Law of Universal Attraction, commonly styled the Law of Gravitation, not only supports this comparison of the amounts of matter by means of weight, but from its having led to results of the very highest importance astronomically and otherwise, has been looked upon as one of the most important laws ever discovered, and modern science may be said to be founded upon it.

To say that I doubt the accuracy of present comparisons of matter AS DISTINGUISHED FROM MOTION, by means of weight, is but another way of saying I doubt the completeness of the law referred to; and having said that, my readers may or may not consider it necessary to proceed further. Possibly, however, if they reflect calmly upon the expediency of opening the door to fair enquiry, they may find reason to modify their views as to the possibility of making all Nature conform to Newton, and may doubt the finality of that deliverance made—we are taught—once for all to the saints of science, as an exact and complete expression of a universal truth regarding attraction.

I promise to be as brief as possible consistent with the necessity I am under to detail many matters as if unknown to some of my readers, seeing that I am addressing all and not merely a few, and am not asking acceptance on my own behalf or for my views, but simply wish to have that elicited which ought to be the end and aim of all enquiry—truth. If at my expense, perhaps few can so well afford to pay the penalty, and few, if any, have so much exposed themselves to that risk. Where you are unable to determine the truth, you can suspend your judgment, and that which is only *reasonably or probably* true, you can admit as being so until you are provided with sufficient evidence to enable you to arrive at certainty.

This universe appears to consist of matter in motion. Though it is almost impossible to consider one without the other, let us first direct particular attention to the subdivisions of matter.

Since the time of Lucretius at least, and probably long before, it has been asked whether matter is capable of *infinite subdivision*, or whether the subdivision if we could

effect it would ultimately bring us to particles so small that they could not be divided further.

That question has never been answered, but chemistry may be said to owe its existence as a science to the laws of equivalence and multiple proportion, which agree well with the latter assumption. We have been led to consider all known matter capable of resolution into about sixty-five different kinds or elements, the atoms of which, regarded as occupying equal spaces, are known to possess widely different weights or equivalent proportions. Little, if any, relationship appears to exist amongst these weights, spite of all the attempts to connect them intelligibly together, of which Mendelejeff's "Periodic Law" is probably the least unsuccessful; and I believe I state the case correctly when I say that it is now or has until recently been held that the differentiation of the elementary atoms is explainable by assigning to them different densities. For instance, the primary distinction between platinum and hydrogen is generally regarded as due to the former having about 197 times as much matter as the latter in the same space, yet we are to think of this condensed matter as constituting an indivisible atom. Then the different atoms of the elements were supposed to have also different bonds, some, for instance, like carbon, with four, being able to hold more monad radicles than hydrogen, which appears to have only one. Beside these, they also had each over a dozen different properties, which were specially investigated by physical scientists.

As I shall have occasion later on to bring before you several results of chemical enquiries, it may not be out of place to call your attention here to the fact that chemistry more than any other science has conformed to Nature's standards, and has flourished as have few other sciences this

century. Its standards and its methods have been under, I might say, daily examination and close scrutiny by most able minds, and their invariably successful application, in conjunction with the atomic theory, has led to imitations of Nature's own productions to an extent which is scarcely less gratifying as evidence of chemical progress than as affording ground for the belief that the progress results from just procedure upon safe premises.

If the evidence of chemistry is in any way contradicted upon atomic questions, specially so far as regards the laws of multiple proportion and equivalence by the evidence of any other science, I shall ask you to consider the greater credibility of the former, which has been so often tested, and which bears upon a subject it is peculiarly entitled to deal with authoritatively.

Chemistry uses as its standards of measurement the atomic equivalents, which are regarded, please remark, as representing subdivisions of matter, and have numerical values attached to them which are known as atomic weights or combining proportions.

Combinations of these atoms, or subdivisions of *matter*, are considered dependent upon an attractive *force* known as affinity. To explain what is meant by affinity, perhaps I cannot do better than quote the alleged distinction between it and gravitation given in a well-known work thus :—"The force of gravitation is exerted *at all distances* between masses of matter without regard to their nature, and differs therefore in every respect from affinity, which may be defined as an attraction *at insensible distances* between particles of matter of different kinds."

We may ask at what point does distance cease to be sensible? and if attraction of gravitation requires to be

replaced by the attraction of chemical affinity when distance is reduced beyond the limits of sensibility or perception, is it not, to say the least, very remarkable that Newton's law of universal attraction appears to be not universal just when we attempt to apply it under conditions which ought to be most favourable to its undisturbed operation, viz., to the case of two material particles which that law is expressly intended to apply to?

Operating apparently as a universal law in other connections, and every physical law being made more or less to conform to its requirements, are we to suppose that gravitation, having apparently only failed where our perception of distance fails, that we must lay the fault at the door of "perception," as many would prefer to do rather than question the correctness of the law of gravitation?

If distance ceases to be perceptible between two particles when they are in actual contact, that is but another way of saying distance may be left entirely out of consideration where it does not exist, and we understand then what is meant. But if the ultimate particles of matter, though obviously the nearest physical approximations to the mathematical conception of a point, may be considered for the purpose of enquiry spherical, and having a radius represented by x, then since for all purposes of gravitic comparison we measure the distances of mutually attracting bodies as between their centres of gravity, we are so far warranted in measuring the distances between ultimate attracting particles also between their centres of gravity, and the attraction due to gravitation will, other things being equal, approach its maximum as the distance between these centres is reduced. Now the ultimate particles or atoms of matter, if we reject the suggestion that truly *atomic* masses have different

densities, are most reasonably regarded as impenetrable and inelastic, otherwise more than one might occupy the same space at the same time, and so defy all our attempts to reason of them, therefore in the case supposed the attraction due to gravitation ought to be greatest when the particles are in contact, *i.e.*, when the distance of their centres is equal to $2x$. But this is precisely the point on reaching which, or approaching within insensible distance thereto, we are presently left to believe attraction of gravitation is either entirely inoperative, or merges into a greater and entirely different attractive force, *i.e.*, affinity, which takes its place. If I am wrong in stating this to be the logical result of present-day teaching, and if gravitation, even when it attains its maximum, is so small when compared with the new force then manifested, that the former may be neglected, it would be better if we were told so. If gravitation and another force co-exist in unknown proportions under the term affinity, that also ought to be stated.

But it is because most of the phenomena of chemistry are unintelligible, unless the law of gravitation is superseded or supplemented by another law of attraction, that the conclusion suggested by the quotation before made has been generally accepted, viz., that affinity and gravitation "differ in every respect."

But what is "gravitation"?

It is necessary in order to understand it, to quote Newton's law, which asserts that "every particle of matter in the universe attracts every other particle with a force, whose direction is that of a line joining the two, and whose magnitude is directly as the product of their masses, and inversely as the square of their distance asunder."

In order to avoid confusion I shall consider all the com-

parisons which I have occasion herein to make of attraction and mass measured by this law to be made at equal distances. That portion of the law which relates to distance does not require to be presently considered, and it will be understood where attraction is spoken of that it is mutual, although, for the sake of simplicity, I may speak of the relative attractions of two bodies for a third, without specially mentioning the attraction of the third body for them.

Before proceeding to consider the force of attraction and its dependence upon mass, it will be convenient that we understand what mass means. The utmost importance depends upon the definition, in fact the whole case.

Mass is a term used to signify *the quantity of matter in* a body, and it is correctly defined by Newton as proportional to the volume and the density conjointly—

$$M = VD.$$

Knowing the value of V, that is the number of units of space occupied by a body, and the value of D, which expresses the number of units of mass that body contains in each unit of space, Newton means that if the body referred to is of uniform density you multiply the number of units of mass in each unit space by the total number of the units of space, and the product represents the number of units of mass in the whole space the body occupies. It is obviously as true a statement whether the individual atoms gyrate or are at rest in the spaces they occupy.

Newton expressly says, "If there is anything which freely pervades the interstices of all bodies, it is not taken account of in estimating their mass." Therefore since mass is a term which properly signifies quantity of *matter*, expressly exclusive of force—as I shall use it throughout these pages—we are, by that which has been held to be an exceedingly important and

suggestive limitation on Newton's part, prevented from supposing he included any of the imponderable substance which he assumed in connection with the emission theory, or of that force, fluid, or ether, which many of his successors have regarded as freely permeating matter.

That it may be clearly understood that *weight* was not intended where mass was spoken of expressly, I may mention that weight, so far as it is capable of being understood after reading the confusing definitions of matter and its properties which form the introductory portion of most books on physical and chemical science, appears to have three meanings. It is used (1) to signify a property of matter; (2) sometimes to denote a quantity of matter; (3) usually and perhaps most frequently in scientific works to denote a "*force.*" Still it is and has been for some thousands of years supposed to be so well understood, so clear, so plain, and palpable, that perhaps we ought to consider the want of definite definition incidental to the attempt to explain that which is intuitive, and ought to require no explanation.

Now can we consider mass to imply a portion of matter necessarily carrying its *properties*, and say weight as one of these, with it into the equation of Newton's law, which appears to give us force of attraction in terms of quantity of matter and inverse square of distance? The admission would be fatal to the law, for since the law is said to apply to all masses, and since those who have the most elementary acquaintance with chemical or physical phenomena must admit that all masses have not the same properties, it would simply make confusion worse by introducing a variable sum total of properties into the equation along with mass. And if only one property is sought to be introduced, reason must be given why all the properties of the mass in question are

not to be also included, especially if the object of the introduction is to effect numerical alteration of factors already existing in the equation.

Can we agree that where Newton has expressly said "mass," meaning and having invariably been understood to mean "mass," *i.e.*, a quantity of matter, that we are to understand weight considered in its third sense, viz., as "force." It is absurd to suppose such great misuse of language.

Or shall we say that which is most probable, viz., that Newton's law of "universal attraction," where "mass" is spoken of, refers to "mass," viz., a quantity of matter, but implies that this mass is to be deduced directly from, and vary directly as "weight."

That is the best construction I am able to put upon the language used; and it is, I think, borne out by the fact that nowhere can I find evidence of any attempt to place any other construction upon it, notwithstanding the fact that almost every physical investigation depends directly or indirectly upon the proper construction of this law. And it is unquestionably true, that although "mass" may be capable of estimation otherwise than by means of weight under certain conditions, yet the results of independent estimation have, so far as I can ascertain, never suggested even to the minds of the ablest modern scientists, any reason to doubt the correctness of the simpler direct measurement of matter by means of weight, because that the former have apparently confirmed the results of the latter, and established weight as the practical measure of mass, which, indeed, Newton asserts it to be.

Therefore if I am able to convince you that there is reason to doubt whether the determination of mass is always correctly made by means of weight, I shall have induced you also to

doubt with me the correctness of the independent estimation of mass so far as its results coincide with the results obtained by weighing.

Now I wish it particularly observed that I discuss the Newtonian law, principally because of the deduction to which it leads, and upon which it is also based regarding the determination of mass, *i.e.*, quantity of matter. And before proceeding to consider the law of gravitation in detail, let me say that as regards the independent determination of mass to which I have referred, I believe it will be found on careful enquiry that the "certain conditions" requisite have not been attended to so as to secure a true and impartial answer from Nature; but whether I am right in thinking so or not, I need not presently stop to argue.

It is with the third term of Newton's equation, viz., the inverse square of distance, that the law itself is principally associated in men's minds, and to which Newton is chiefly indebted for the undying fame of the entire law. The law of inverse squares itself is indeed a most beautiful law, and it enters into almost every physical science, but it is nowhere seen to so great advantage as in the science to which it primarily belongs, and from which it was borrowed, viz., pure mathematics. It is there seen to depend upon the geometrical principle that a spherical surface increases as the square of its radius, a truth which is at least as old as Euclid.

This principle has been applied to the measurement of light, heat, magnetism, &c., by comparing the surfaces upon which they were incident, not always, we may remember, with the same complete and satisfactory result that attends its geometrical application.

Passing over the fact that it has never yet been shown that if we had matter without force of its own, it could

either attract or be attracted by other matter at all, we find that to determine mass becomes the question of paramount importance where we require to measure attraction by the aid alone of Newton's law. To determine mass it has always been, and still is, considered beyond all question the proper course to deduce it from weight, as reference to Newton and all authorities will show. But weight, considered in its ordinary and presently proper meaning, is a compound of mass and earth's attractive force. Representing the latter by the letter "g," weight by W, and mass by M, the value expressed algebraically stands thus—

$$W = Mg.$$

I do not think we are much further forward, because g or the value of the force of attraction we are going to determine by Newton's law, that is why I am seeking just now a value for mass. If we compare two weights for the purpose of establishing a comparison of their relative masses, what happens? This :—g being common to both as the expression of earth's attractive force, cancels out, and, as the authorities say, weight therefore varies as mass. But this is circle sailing with a vengeance. We asked weight for a value of mass, and we are dependent upon mass, and earth's attraction for a value of weight. We must get out of this vicious circle if possible, for if mass depends upon itself indirectly for its value, how shall we determine that value when unknown?

Surely so far as concerns the application of Newton's law to the determination of attraction, we cannot place it under more favourable circumstances, distance being known, than by inserting a value of mass which has been obtained by means of, or in accordance with, the law itself, therefore let us consider present methods of determining *mass* in detail.

I will suppose for the present that the force of attraction

is known as the result of the investigations into the law of falling bodies or pendulum motion, and that earth's gravitic attraction may be expressed as having a known value, say "*g*."

Gravity and distance known, find mass from the equation of Newton's law. But stay. How does the attraction of gravitation act? Does it act by or through a motion of translation towards the earth in straight lines of those corpuscles which formed the stock-in-trade of the believers in the exploded emission theory? or does it act through communicated vibration or wave motion in conformity with the undulatory theory now firmly established for other forces?

If by neither, how does it act at all?

If the attractive force of gravity is not propagated by wave motion, I shall have to ask more unpleasant questions not easy to answer, but it cannot be explained at all, you will find, without the aid of the undulatory theory, unless by further confusing the results of experience in every branch of physical science.

Then if it is propagated by wave motion, are the waves simple and of one constant order, may I say homogeneous? or are they superposed waves of different orders, constant only in the sense of being a succession of resultant waves due to combination of a number of heterogenous waves?

If the former is alleged, then I ask how far it is safe to assume the action of a simple and constant system of gravitic waves can be equal on two bodies of equal mass if they hang in the respective pans of a balance, but chance to have different atomic vibrations of their own. Would not the gravitic wave force of earth, even if supposed uniform and homogeneous in itself, act differently upon two equal masses in such a case owing to the want of equality in the vibratory motions of the unit masses compared?

If not, why not, and what reason can be assigned for the contradiction of the established laws of motion which the denial involves?

Similar but still more serious questions arise, if the gravitic force is admitted to be propagated by a superposed system of heterogeneous waves (such as will be spoken of later herein), and yet alleged to have an equal effect upon two unit masses vibrating in different periods.

I take it for granted, however, that my readers must admit gravitic force to be propagated by wave motion, like other physical forces; and, further, that gravitic wave heterogeneity will be admitted to involve the least violence to common sense when the heterogeneity of the earth's components ~~are~~ is taken into consideration.

Two bodies are said to have equal masses when they counterpoise each other in a perfect balance in vacuo, *i.e.*, when their weights are equal.

This weight is said to be the effect of earth's attraction for the matter contained in the respective pans of the balance, acting along lines which are practically parallel, and we are warranted so far in applying the rules for the composition of parallel forces. But admitting for the moment that the earth's attractive force may be considered in such a case as a constant, existing quite irrespective of the matter introduced into the pans of the balance, I have yet to learn that the same force necessarily exerts the same action on equal amounts of what are called different kinds of matter, other things being considered equal. There is not one science, neither is there one fact or law of science, whether chemical physical, biological, or otherwise, I can find which does not distinctly point to the opposite conclusion, or which is not capable of possible reconciliation therewith, save where

they have been affected by the operation of the law of gravitation, which is itself founded upon the assumption it formulates, that gravitic force acts equally on equal masses or quantities of matter, ignoring all atomic motion, and consequently all differences of chemical constitution.

When the correctness of this assumption has been proved I will admit Newton's law to be correctly stated, and until this is proved—and I believe it is incapable of proof because untrue—I shall hold, and ask you to believe it possible, that the claim of Newton's law to be the true expression of universal attraction requires investigation, and must be held not proven, if not even rejected, in the meantime. That in Newton's time there would appear no reason to doubt that gravity acted equally on different kinds of matter is only natural, but that so many thousands of scientific workers have succeeded him, so many sciences come into existence, and such important discoveries been made without any proper attempt to revise Newton's law, is only to be explained by the fact that whether the law is or is not universal, its acceptance may be described as being so. If Newton had lived in our time and been acquainted with the various kinds of matter and force recognised in sciences which were unthought of in his day, he would have known better what an infinite variety of phenomena a law of *truly universal attraction* is bound to meet.

Cavendish's experiment is supposed to have confirmed Newton's law. Cavendish asked Nature whether matter attracted matter in accordance with that law. Nature was understood to answer in the affirmative, as also similar questions put by others. But these experiments were very costly in proportion as the favourable conditions they were made under increased, and they were very few, insignificantly

few, when compared with the importance of the law involved. And Nature was not asked if gravitic attraction was affected by difference of chemical constitution.

In Newton's time there existed neither the incentives nor the facilities for such an enquiry that exist now, and when it is remembered that the applications of his law have led to results of the highest importance and apparent exactness, it is not to be wondered at that no one will listen to the suggestion of its possibly involving a fallacy.

Yet just as the accepted views of the solar system in Galileo's day had to give way to views which he enunciated, and for which he received the usual thanks, so also the so-called law of universal attraction must give place sooner or later, probably, of course, later, to one which shall be infinitely more comprehensive, simple, and true, and therefore better entitled to be called universal.

I am impelled to speak thus because I find that there is considerable contradiction between the results of certain chemical and physical investigations, which I find eminent physicists are trying to explain, by suggesting doubts which, if not reflecting upon Nature, reflect upon chemical science, which is in closer harmony with Nature's truth and order than their suggestions would lead us to suppose. Some of these suggestions carry in themselves the evidence of their own inadequacy and untruth to the minds of those who are acquainted with the sciences to which they relate; and the transparent absurdity of others must be evident even to the meanest capacity. If we are to make assumptions let us at least assume the fundamental unity, order, simplicity, and harmony of Nature, yet not rest content without finding proof, if such can be had, by asking for it plainly in the proper quarter.

I have not succeeded in satisfactorily deducing mass from Newton's equation and application of the formula $W = Mg$, though others may be able to do so, and earn my thanks by showing me how, if I have not done justice to the method. I have so far endeavoured to show that the Newtonian law involves the assumption, based upon his experiments with pendulums weighted with various kinds of matter, that gravitic force acts equally on different kinds of matter, which is a most serious fault, quite sufficient to justify your holding the law, spite of all its successful applications, open to possible correction or replacement. I shall now proceed to submit a more serious indictment against it as applied to the estimation of weight.

Newton's law being particularly concerned with the gravitic force of one particular body, our earth, *he* taught us, and thousands since have believed on him, and added the authority of their names in repeating his instruction, to regard the earth's force, where distance is not considered, as a uniform, and, let me say, homogeneous force. This force we have been taught to regard as capable of representation geometrically in magnitude and direction by straight lines, to which the principle known as the parallelogram of forces might be applied, the said lines being for ordinary purposes considered practically parallel, though when continued really convergent upon a point known as the earth's centre of gravity. Such representation may have been convenient in connection with the exploded emission theory to which Newton lent his powerful support, and which assumed the propagation along right lines of imponderable molecules of extreme tenuity but I apprehend you will require something a little more complimentary to your intelligence now, or in the not far off future.

I suppose I need not write a complete treatise upon physics to show you that the phenomena of sound, light, heat, electricity, and magnetism are justly regarded as capable of satisfactory explanation only in connection with wave motion —vibration. Gravity alone of all the physical forces has, for some—to me inscrutable—reason, been excepted. I cannot conceive the existence of gravitic attraction save as originated and propagated in connection with vibration or wave motion of matter, even though the intervening matter be in such a state of exceeding tenuity as to admit of concealment under the magic thimble of the term ether.

Is the earth's force propagated by vibration, or is it not, I ask again? We do not know, but we have infinitely greater reason for believing it is, than accepting the suggestion that it is not, whether that suggestion be Newton's, or that of any of his many worshippers, ancient or modern. I will give specific reasons for the belief presently, but I will repeat another question first, and then attempt to meet both together.

If the earth's attractive force is propagated by wave motion, is the force uniform, or as I would prefer, if allowed to say, homogeneous in the sense of consisting of waves all of the same amplitude or period?

I reply—

1. That the earth's attractive force *is* propagated by wave motion; and

2. That this wave motion is not homogeneous save so far as that term might apply to a compound wave force considered as the resultant of the superposition of a number of heterogeneous waves.

One reason I allege is, that the atoms of matter must of necessity be considered to be possessed of force, otherwise

whence the force their aggregates possess. Matter without force is not known to us, neither is force known to us without matter, though for scientific purposes they are sometimes spoken of as if capable of separate existence. Chemical, electrical, thermal and spectroscopic considerations combine to show that matter manifests its existence to us only by the resultant wave motion of component particles. Our earth is an aggregate of such particles or elementary atoms, and its mass is obviously the sum of the masses of its component atoms, its force the sum of their forces.

The earth's atoms not being necessarily arranged so that the elementary vibrations are all at one time in the same phase, and the vibrations being various, their algebraic sum may be compared to that of the vibrations due to the different musical notes proceeding from an orchestra towards one of Helmholtz's sound resonators, so far as they are related to a particle having a particular rate of vibration of its own on which the assumed gravitic waves are incident. Similar analogies present themselves in every science which treats of force, and it matters not whether the resonator be a vapour, a thermopile, an induction balance, an actinic or a fluorescent body; and though I shall not presently press it upon your attention, I have found it more than useful to extend this list to explain the operation of all force, without any exception, upon all matter inorganic or organic, whether the resonators are the atoms of a zoospore, a leaf, a comet, or those of a conscious organism, which latter otherwise pass through the meshes of the net of evolution, with a facility which the speculators who have invested so largely in stocks of "imponderable ether" and "electricity" have abundant cause to regard with envy. I refer here of course to electricity considered in its proper sense as "a mode of motion," not to

electricity in its ordinary sense, considered as "a cloak of ignorance."

Returning, however, to the question whether the earth's force is propagated by wave motion, I have referred to present chemical and physical science as proving the reasonable probability of its component atoms all being in motion when considered separately, and it infinitely transcends the bounds of all reasonable probability that so heterogeneous a mass can be considered perfectly at rest as a whole, if its parts move.

If the parts manifest their existence by wave motion, why should not the whole manifest its motion in the same manner, and if the component waves are diverse, their resultant must be a system of superposed waves, or its equivalent, a compound wave.

I ask you to believe this as at least reasonably probable until gravitationists can supply you better evidence in favour of the opposite view. Presently there is no evidence whatever to the contrary, therefore the prejudice in favour of the contrary is infinitely great in accordance with the mathematical doctrine of probabilities as applied to the usual relation subsisting between absolute knowledge, and prejudice, in the equation of truth.

Still it may be replied that I have not proved the earth propagates wave force. If I grant this, I reply that it is well nigh impossible to show it, even if true in language, every term of which bears more or less plainly the mint-mark of that system which is founded on the opposite belief. If our earth does not propagate wave force, it is the only member of the solar system which does not, as any spectroscopist can tell you; he will also show you, at the same time, that the waves of force he analyses from bodies celestial are various and superposed.

The amount of reasonable probability then is greatly in favour of the belief that our earth consists of atoms in vibration, that the earth propagates its force by wave motion as its individual components do, and that its resultant force is equivalent to a system of superposed waves.

Some will object that this view can be reconciled with Newton's law by regarding mass not as an expression of matter but as a product of matter and force. So it can, and if it had not been so, I think the law would not have explained so well as it has hitherto done many phenomena of the universe, where atomic force supplemented atomic matter, and preserved an atomic constancy, concealing the defects of matter by permitting it to draw upon the bank of force. But this would represent Newton's law of gravitation as giving the equation of attraction in terms of a product of matter and force, and inverse square of distance. If mass is to be regarded as consisting of *matter* and *force* multiplied into each other, how much of it is matter and how much of it is force? A product of 60, for example, enables us to say, if the matter involved is 12, the force is 5; if 20, the force is 3; and last, but not least important, if 1, the force is equal to 60. But where we know the product only, and the value of neither of the components, how shall we ascertain the relative amounts of each?

1. If mass, considered as a product of two factors, were all matter save unit force, the latter might be disregarded for comparative purposes without denying the existence of force, and Newton's law would be unassailable to that extent.

2. If mass, as such a product, contained unit matter, then the rest would be force, and matter might be disregarded for comparative purposes without denying its existence. This is by far the most preferable course.

3. If mass is but the product of x, an unknown quantity of matter, into y, an unknown quantity of force, then we are in hopeless confusion, since the value of x depends on knowing y, and y on knowing x.

Of these three courses it may be said the first contradicts chemical, optic, thermic, and electrical science, because it implies that the particles of matter all have the same force or motion. The second and third require us to bring the laws of motion into the consideration of *mass* before we can use it to determine attraction by means of the equation of gravitation. Again, if mass is synonymous with force, why call it matter, and if part force and part matter, why not say so?

If you are still quite sure that Newton's law is established as a correct statement of Nature's law of universal attraction, it would be convenient to proceed no further at present, and take this up again fifty years hence. Perhaps before then I or some one with more time and opportunities, may have given you better reason to believe that which I presently try to show, viz., that it is not *the* law of universal attraction, but merely a particular case of Nature's higher and more general law.

What may the higher law be?

I will take three equivalents from the chemist's laboratory. One called a lithium atom, one a potassium atom, and the third a chlorine atom. I produce certificates of their present indivisibility endorsed on behalf of every physical science, and of their equivalence endorsed by chemical, electrical, and thermic science in particular. Note particularly, they occupy as taken, equal unit portions of space.

I propose to compare the masses of two of them.

Obviously either the ultimate analysis of this complicated cosmos, assuming it to be finite, brings us to the homo-

geneous, or it does not. Hitherto the difficulty has been, so far as I can see, not to conceive the possible existence of homogeneity (if I may use such a term) as regards abstract motion, but to give a sufficiently intelligible account of that material heterogeneity which appears to underlie chemical and consequently universal science, on any hypothesis involving the conception of an ultimate homogeneity of matter.

To offer an atom of sodium in exchange for half an atom each of lithium and potassium, because sodium's equivalent is nearly a mean proportional to those of the other two elements, was as ingenious perhaps as the suggested division of a material atom in the proper sense of the term is physically and logically impossible, and to say that all chemical elements were modifications of pantogen was a happy guess, easier to make than to justify.

Possibly the charge of materialism so often urged as the result of the ultimate analysis of modern science was an equally happy guess on the part of those whose disinterestedness would have saved us the trouble of any analysis whatever.

I speak thus, because the atomic heterogeneity seems to me, as the result of long enquiry, a heterogeneity not of matter, but of expressions of earth's attraction upon those atoms. We may, I think, if we examine attentively, see the material atoms to be indeed atomic, and the material homogeneity to exist in the heterogeneous elementary atoms, as easily as we may conceive heterogeneous curves described by the motions of homogeneous points.

But if we thus avail ourselves of atomic motion, the opponents of scientific progress may awake to the knowledge some of these days that science, if it throws off the materialism which attaches to the Newtonian legacy, is able to leap

over, and will leap over, the barriers which hitherto it has only looked through.

In the meantime it is necessary to proceed with the enquiry as to the masses of the three atoms before us, and having first asked Ampère, Dalton, and Dulong to examine and report to us that they are strictly in accord with the certificates mentioned before, and specially as regards present indivisibility, chemical equivalence, and equality of volume, let us forget Newton's law, and ask what amount of matter Nature is likely to have put into each unit space. Common sense and experience of Nature's operation combine with logic to answer, Unit mass in each. Then if each unit space is occupied by unit mass, what are the atomic densities? Unit densities, logic replies. Very well, nothing doubting that we have a material homogeneity, we proceed to examine into the cause of the differentiation as regards properties. At first all the atoms seem at rest, and we note the different properties they have, without finding reason to doubt their equal densities. We examine them spectroscopically, note their electric equivalence, specific heats, diathermancy, specific inductive capacities, &c., &c., and are driven to ascribe their properties to their various motions and phases thereof, when in comes Newton, knowing nothing about specific heat, chemistry, electricity, &c., and suggests we ought to weigh them.

As there must be gravitic phenomena analogous to diamagnetism, &c., I purposely avoid "specific gravity."

We weigh by *substitution* in hydrogen units, and find lithium = 7, potassium = $39\frac{1}{16}$, chlorine = $35\frac{1}{2}$.

Ah, then, Newton suggests that is because the amount of matter differs in each, and, if we venture to suggest, Newton may be wrong, and Nature misunderstood, someone is sure

to refer us to the respectability of Newton, and suggest that in Nature nothing is impossible. The latter suggestion is ever useful where those who make it have some theory to ventilate unworthy of Nature, but which is all right so long as Nature can be made to seem to fit it.

But we object that chemistry and physical science alike suggest that which logic no less than a belief in the simplicity and order of Nature requires, viz., that these elementary atoms which we took all of equal unit volume, remember, have equal unit amounts of matter, that is, equal masses. Then so much the worse for Nature, chemistry, and logic, for they must be made to fit Newton's law at any cost. Then we ask how we are to get over the difficulty. Mark the exquisite beauty of the explanation (?) which is given. It is this—"Granting that your measurements are correct of the spaces the atoms occupy and their perfect equivalence, Nature has put 7 unit masses into the lithium atom, squeezed $35\frac{1}{2}$ unit masses into the chlorine atom, and $39\frac{1}{10}$ units into the potassium atom." No wonder chemistry so long accepted this doctrine of different atomic densities. Its brilliancy causes not only the light of chemistry, but also the light of electric science, to become as darkness in comparison, and the very orbs of space pale their ineffectual fires before its glare, or seem to twinkle as if conscious of the comicality of the conclusions it leads to regarding their density.

Condensed matter is peculiarly susceptible of explosion. I tremble when I think of the effect of dynamite upon *atoms* so fearfully and wonderfully condensed as these.

But how is the conclusion arrived at that the amount of matter varies so curiously in equal spaces for different elementary atoms? 'Tis thus.

First satisfied of the equality of the spaces occupied by these atoms we seek to compare their masses, and we are taught to do this by weighing. Say first we require to compare the mass of a lithium atom with that of a potassium atom. Instead of making a direct comparison we make an indirect one. We have been compelled to introduce a third mass, and that mass the earth's, and weighing proceeds upon the constitution of an equilibrium of forces therewith.

Comparing their relative attractive forces for the earth, and of the earth for them, we get what is known as their relative weights, viz., 7 and $39\frac{1}{10}$, and are certified by Newton's pendulum experiments that 7 and $39\frac{1}{10}$ are therefore their relative masses. But this weighing involves the assumption that the earth's attractive force acts in the same manner upon both elements, and this assumption is, as I have said before, a most unwarranted one, and is a contradiction of the whole of physical and chemical experience as regards the action of other forces, and utterly at variance with the facts connected together under the law of exchanges.

If it is true, as it obviously is, that the amounts of matter in the lithium atom and the potassium atom which we desire to compare are unaltered, whatever the standard of comparison may be, we have an equal right to use any other body instead of the earth for the purpose of obtaining the equation of attraction which is supposed to give us a direct measure of mass.

Carrying out strictly the same principle, viz., the introduction of a third body, I elect to use an atom of chlorine instead of the earth. Practically, the result is an *equivalence of attraction*, or *weight* in terms of what I may style chlorine gravity, and if I take any other atom instead of chlorine I get a similar result. But I am told I must not compare the

amounts of matter in the lithium and potassium atoms thus, but only by using earth's attraction. Do those who suggest this know what it implies?

If, then, in terms of chlorine attraction and all other chemical attraction we have an apparent uniformity and equivalence of weight, that by parity of reasoning suggests equality of mass, shall we be compelled to set aside that conclusion because the injudicious advocates of a law of miscalled universal attraction say there is only to be one standard of comparison for mass, viz., our earth? The suggestion is unworthy of the law and of him whose honoured name it bears. Suppose we were comparing the relative masses of the lithium and potassium atoms on the surface of Sirius, would it be necessary for us if we found, as no doubt we should, a different system of wave motion was radiating from it, owing to its composition being dissimilar to that of our earth, and resulting in our obtaining a different relation as regards weight between the atoms, to assume that the masses compared had also altered? 'Tis more than absurd to suppose so. If Cavendish had compared the masses of equal unit volumes of hydrogen and oxygen by introducing an enormous globe of lead instead of the earth, and taken every precaution to exclude the effects due to the field of force in which all terrestrial operations are necessarily conducted, I do not think he could have arrived at the conclusion that there was 8 or 16 times as much matter in the oxygen atom as there was in the hydrogen atom. He might, but I think it exceedingly improbable.

I confess my utter inability to understand why the universe should not be regarded from a loftier standpoint than that of this insignificant earth of ours, if we can only use our intellectual power to break the chains that earth's attrac-

tion has rivetted upon us, and soar aloft in search of a point from which to obtain a better view of Nature's operations.

No doubt those who will be most anxious to avoid the conclusions to which the suggested principle of selective wave absorption leads, when considered in connection with chemical elements differentiated only by their rates of motion, will be those whose belief in gravity is most securely established. The same people for all that would be foremost in condemning the views of those who of old made earth the centre of the universe, and the sun and all celestial bodies to exist only for its sake, and be in every way dependent upon it. Those who advocated such views had not the light that we possess; shall we then perpetuate views of Nature's operations, which begin by suggesting atomic disorder and chaotic nonsense as the elementary basis of the whole universe? It is a gross libel upon Nature, only capable of acceptance in the interests of an established system, the advocates of which would render hopeless the attempt to pass the hitherto unopened doors of Nature's treasure house by ruining the locks in their vain attempt to open them with a gravitation key that will not pass their wards. How many locks have been deranged by it already, and how many have been tinkered to suit gravitation, the history of science for this century may some day show in a clearer light.

Then, when at last the hole is perceived in the millstone mass, we shall have it alleged that weight did not mean this, and density did not imply that, and mass was intended to signify the other, and that in fact the terms used in the introduction to the knowledge of matter and force given in scientific and other works are characterised by nothing so much as an ambiguity embarrassing to the student, but eminently qualified as regards their elasticity to accommodate themselves to anything, except, perhaps, *truly universal* attraction.

But you will ask, if you admit the fallacy underlying Newton's law, and the comparison of mass by weight in the ordinary way, how has it fitted so well hitherto the phenomena of Nature? I reply, Because it has so happened that a product of matter and force simulated mass in most cases, and where this was not the case, and gravitation did not fit Nature, why, Nature was just made to fit gravitation.

Reminding you again of the emission of superposed waves of force by all celestial bodies, let me instance those we receive from the sun.

There we have sodium, potassium, calcium, iron, &c., &c., vibrations travelling together as superposed waves without destroying each others' effects. These waves are known as waves of light. Since the wave length of the violet constituents is about half that of the red constituents, the luminous rays have been spoken of as comprising an octave of vibration.

When suitable resonators were placed in the ultra red and ultra violet regions, other octaves of vibration were proved to exist which had not before been recognised. But these octaves of vibration are all situated together, if I may be allowed the comparison, near the extreme treble end of the key-board of a natural pianoforte, which comprises the vibrations we know as sound, from that of the lowest note of an organ pipe, up to the shrill chirp of a cricket, all deep down amongst the lowest octaves of its extreme bass. Between the highest acoustic octave at the lower end, and the lowest octave involved in the phenomena of heat, light, actinism, &c., at the upper end, we may realise by comparison of wave lengths that many octaves appear at present unutilised.

But the notes that appear to be wanting from the key-board represent so many possible rates of motion, which there

can be no reasonable doubt Nature uses in her infinitely grand orchestral music, although our eyes and ears may not be adapted to their reception. But precisely as we can distinguish the individual sound waves by means of Helmholtz's resonators and manometric flames, although existing as part of a superposed system of heterogeneous waves, so, no doubt, we shall yet be able to show the existence of the notes apparently wanting when we use the proper resonators.

Although, from the extensive knowledge I assume my readers possess, a description of König's apparatus as used by Helmholtz in the analysis of superposed waves of sound may appear superfluous, yet as the simplest instance I can give to explain the principle which I allege underlies gravitation and affinity, I give it shortly, for the sake of those who, not knowing it, might otherwise miss the chief point of my argument. Cylinders, each capable of resonating different specific rates of vibration, known as musical notes, are connected separately with supply pipes carrying gas to small jets of flame. Mirrors rotate close by, and the reflected images of the flames are examined while the mirrors are in rapid motion. If a note, say C, is sounded, the resonator of the vibrations corresponding to C responds, as is shown by the image of the flame connected with C being altered, while the others, save so far as they are affected by C's harmonics, remain uninfluenced. Sound the note G alone, and the resonator of G's vibrations responds. Sound C and G together, and resonators C and G respond together, and so on. Let an orchestra perform before this apparatus, the resonators each select and respond to their own particular notes and harmonics. Thus, also, atoms to each other, to the earth, and to the various physical forces.

It appears more than probable that the germ, the cilia, the

leaf, the cell, &c., are each resonators of rates of motion, owing their existence, shape, and properties to their constituent's motions, and their relation to the rates of motion existing in their immediate environment in particular, but also in part, to all other rates of motion existing universally.

A thousand illustrations might be given, but one will suffice to indicate my meaning. In a film of gelatino-bromide of silver, as used for photographic purposes, specific rates of motion of the ultimate units of silver and bromine therein would be the principal factors to be considered, their relation to the rate of motion existing in the gelatine in their vicinity would require to be considered next, and, finally, the relation of these to the resultant rate of motion of all other matter in the universe, although the rate of motion, answering to actinic light vibration, will be that component of the latter specially active in determining the effect as regards motion of re-arrangement in the film, if the plate be exposed to daylight in the field of earth's gravitic force.

If we take such a film and subject it to pressure, friction, heat, electric or magnetic influence, we obtain results capable of being understood by regarding all these as so many varieties of motion; and if we subject the film to the influence of gas, vapour, moisture, chemicals, or contact with different solid substances, there seems no reason to doubt the results will be found consistent with the analysis of the interaction of the wave motions associated with these latter upon those associated with the constituents of the film and its environment.

When physiologists recognise the importance of differential attraction and dynamic sympathy as underlying the whole of the phenomena they investigate, medical science may come to be less empirical. But as there is no science that does not deal with matter or motion, or depend for its abstractions

ore or less upon their mental equivalents, so there is no knowledge that is not concerned with, or affected by, anything that tends to throw light upon the atoms and their motions, which latter are the essential factors of the universe.

It must be understood that the instance above given is but one of innumerable instances that may be framed to suit the exigencies of universal phenomena, and if it is objected that such views ought to lead to the transmutation of the metals, and that hydrogen ought to be capable of conversion into gold by mere alteration of atomic motion, I shall reply that we do not possess, or do not know that we possess, any means of effecting the alteration of the periodic motion with which they have been endowed by Nature, nor do we know that if we did effect such an alteration it could have more than a momentary existence.

Although I do not deny the existence of matter, it may be objected that the theory of universal attraction advanced as primarily dependent upon—1. Phase of vibration as regards its positive or negative character; 2. Specific rates of motion of unit masses and the sympathy (synchronic or harmonic) existing between them—suggests the possibility of dispensing with matter. I am aware some have guessed at the possibility of dispensing with matter altogether. I see no reason for so doing, but I recognise matter only as a much less important factor in the cosmos than motion. I cannot deny the existence of matter if I would, and I would not wish to do so if I could. And it is specially necessary that I should desire to retain it, since without it the second factor motion loses its significance.

Motion I use herein to imply a series of positions occupied in succession by matter. Force I use simply to imply

"motion," and should prefer to leave it unused were it not that it is convenient in so far as it serves to refer to motion propagated by matter not always classed as matter, viz., that which is comprehended in the term ether.

Where I have used the terms "force," "attractive force," "gravitic force," "weight," &c., in discussing the Newtonian law, I have in order to make myself better understood, though it may seem paradoxical at present, used the ordinary language of science without particularly endeavouring to free the terms from their inherent ambiguity, wanting which they might not receive that desirable recognition which usually attaches immediately to currency, whether in coin or language.

I am afraid that in my haste to prepare these pages for the press I may have committed many errors as regards style and expression, for which I ask my readers' indulgence for three reasons :—

1. Because I have laboured throughout under the consciousness that I was endeavouring to show the incorrectness of the most important and fundamental law of science, and so incurring the opposition of all those who, like myself, have been taught to regard it as the rock upon which science was firmly and immovably built.

2. Because I am limited to the use of terms which have come to be used as the more or less direct equivalents of ideas which are based upon and presume the correctness of that which I try to show is incorrect.

3. Because accustomed rather to form than to express ideas, I feel my utter inability to impress upon you, as they deserve, the arguments against the received doctrines of universal attraction, mass, and condensed atoms.

If I have said too much and appeared to make unnecessary repetitions, it has been with a view to make myself under-

stood as far as possible by those readers who may be unacquainted with scientific matters. Where I have said, as on the whole I certainly have said, far less than I might, I ask those who are acquainted with the facts and phenomena which Mr Spencer has endeavoured to connect together in his admirable "System of Synthetic Philosophy," to remember that I write under the consciousness of the responsibility not only of attempting to show the fallacy underlying gravitation, but also of seeking to correct the errors and limitations which its influence, by suggesting the differentiation of the chemical elements by differences of shape, size, or density, has caused to attach hitherto to the application of the theory of evolution.

It is my intention, as time and opportunity permit, to follow up this subject by showing the most important deductions which immediately arise from it:—1. In connection with the chemical and physical sciences; 2. In connection with this world and the worlds surrounding it; 3. In relation to organic matter and its environment; 4. In relation to all the properties and attributes of life and the sympathies that underlie all its associated forces.

That which I have written is of sufficient importance—though it may not seem so to all, if to any, at present—to justify its immediate publication, without waiting to polish up its expression or draw up a list of its special applications. It purports to be a key to the problem of philosophy. If it appears, when tried upon any of the locks of Nature, to stick in them, as so rough a casting may, consider first whether the locks have not been spoiled by previous forcing of them with improper keys, and in no case force this into any. If you find yourselves unable to turn it in locks not already deranged, rather condemn it, than tinker the locks. The

metal of which it is made has been refined in the blast-furnace of chemistry and hammered by the irresistible power of electro-dynamics — processes undreamt of in Newton's time—before being used to make a casting from a mathematical pattern in the mould of my weak expression. The metal, therefore, has a value which is independent of the particular finish of the casting I have made, and is greater than that of the base alloy "mass" which Newton used in casting the gravitation key, as the only material for the purpose available in his time.

In considering the effect of the reception of waves of motion by particles possessing wave motion sympathetic therewith, I may borrow a term from any of the sciences which present similar phenomena—I may speak of it as absorption, assimilation, appropriation, &c., &c., or resonation. I have used the latter term, not as suggesting that the propagation or reception of sound is directly analogous to all force propagation, for we know it is not, but because wave motion is common to all these ; and I speak of resonators as most suggestive of the means at our disposal for demonstrating the music of Nature.

But the question arises, Can vibration influence attraction ? Study the phenomena of magnetism, electro dynamics, actinism, growth, &c., &c., and the question becomes unnecessary.

That the phase of the wave motions determines whether attraction (positive attraction) or repulsion (negative attraction) takes place is demonstrated by Ampère's experiments on parallel currents and electrolytic experiments in general, by the recent hydrodynamic experiments of Bjerknes, and the pneumatic experiments of Stroh.

Some may hold the Newtonian law is unassailable on the ground of its having stood all the tests to which science has

subjected it (with perhaps one or two exceptions), and that fact must be held to disprove any rival doctrine founded upon atomic hypotheses as also to invalidate any adverse conclusions based upon the apparent exceptions. Galileo did not abolish the sun when he said the earth moved, though the upholders of the antiquated system he exploded acted as if he meant to abolish both. When soda was shown to be capable of resolution into its elements, its relation to the acids with which it forms salts was not destroyed, although the views of those who had assumed soda to be an elementary body were inconveniently disturbed. So, also, if Newton's mass is shown to be capable of resolution into an equivalent amount of matter and motion, it will not affect the operation of his law in that particular connection to which it properly belongs, though it certainly must cause, sooner or later, a peculiar operation of the law of natural selection, as regards scientific and other theories. I anticipate an ultimate survival of the fittest in proportion to their power of resonating the distinctive vibrations which are the exponents of their environment in the mental, as they are of the facts they connect and lead up to in the physical world.

Before concluding I wish to make a few remarks which might more fitly perhaps have been distributed in their proper places in the preceding pages.

The distinction presently made between the attractive and the portative force of a magnet is comparable in some respects with that made between the attractive force and the affinity of matter. Sensible distance is recognised in the former but not in the latter cases. Vibration alone serves to connect intelligibly the force a magnet exerts at a distance with that much greater force it exerts upon a body in actual contact. Why, then, should we cling so tenaciously to the idea that

gravitic force and affinity require to be explained by ascribing different properties or forces to matter. The one essential and inalienable property of matter is motion, disguise it as we may under mountains of technical expressions and learned ambiguities. In what respect has it been shown that the varieties of motion which are indeed infinite fail to account for all cosmic phenomena, or are incapable of possible reconciliation therewith, as we shall clear away the venerable cobwebs with which the scientists of the past connected the experiments within their reach?

These cobwebs caught the flies for which they were spread, but do we need to allow them to obstruct the light of science, because we admire the ingenuity manifested in their original construction? Theories, like cobwebs, have their uses, but when they fail to catch the flies of fact their utility may be doubted, their meshes modified, or their materials used to construct others suited to the exigencies of scientific existence.

Dulong and Petit have shown that the specific heats of the elementary bodies are inversely as their combining weights, and that the product is (with perhaps seven exceptions) a constant quantity. This is spoken of as the atomic constant, and but for the existence of this constancy, chemistry would, I imagine, long since have required to investigate the constancy of Newton's mass, which, I believe, it has helped to disguise.

As an instance of the fallacy involved in estimating mass by attraction, without taking into consideration the possible differential action of the third body introduced in order to establish an equilibrium of attraction, where the masses compared are chemically different, take the following:—

We require to compare the mass of a unit volume of iron

with that of an equal unit volume of lead, and we introduce a third body, say a magnet instead of the earth, without considering a possibility of differential action. We find if the atoms are suspended from an imaginary pair of scales—with the magnet below—that the iron atom is attracted most. We are warranted by Newton in concluding that there is more matter in the iron atom than in the lead atom, a conclusion rejected equally by ordinary weight comparison, chemistry, and logic.

It is no use trying to avoid the difficulty by saying it is magnetism, not weight, that is here determined. It is one of an infinite number of cases of attraction measured by a supposed universal law, and those who object to the introduction of a magnet, deny the universality of Newton's law and method of mass measurement.

I may equally object to the introduction of the earth until it is shown to possess no differential action, if that is the fault alleged against the magnetic method. Newton's pendulum experiments have no more proved the earth free from differential action, than the apparent parallelism of plumb-lines prove the earth to be a body with a level surface.

The suggestion of atomic differentiation by density has led to classification by supposed arrangement of component inseparable unit masses, which again receives countenance from the observed symmetrical arrangement in crystalline form of their aggregates, but this does not affect the suggestion of ultimate material homogeneity and its differentiation by rates of motion.

If the primary differentiation of matter is merely one of shape or extension, how can it be shown? Surely not by mere consideration of the shapes of aggregates. It would not follow that because a cubic crystal presented a rectangular

section after cleavage, and down to the lowest point of subdivision observable by microscopic aid, that its ultimate particles must necessarily also have a rectangular section, any more than it would follow that the ultimate mental analysis of a pentagon must result in pentagonal points. Geometrically, we can by the motion of undifferentiated points describe all varieties of form, so from ultimate material homogeneity we may possibly, by assuming merely differentiation by motion, synthetically account for crystalline and all other forms without committing ourselves to the doctrine of condensed atoms.

It is not necessary here to consider in detail the motion of the ultimate units of mass. Whether, if spherical, they merely rotate with immense velocity upon their axes, whether they move only through an orbital path, whether they possess both these motions together as our earth does in its orbit, or whether the motion is otherwise definable is not yet certain. Sufficient for me they all have different rates of motion, and all influence the resonators of the senses by communicated vibration. Their motion is not recognised in the determination of matter by weight, although there can be no doubt it is the periodic motion rather than the matter that is the chief factor to which gravity as well as affinity are related, and by which alone they and all other forces have the power of acting through, with, in, or upon matter.

If we consider the chain of evolution as pendant from mass, and if we consider the topmost link to be atomic differentiation, and its attachment to the homogeneous as made by gravity, it will at once be seen that we can neither alter the first link nor interfere with its attachment without involving the safety of the whole chain. And when we take from the mass aforesaid that matter which has been supposed to be its

very substance and strength, as also it was the material of the chain itself, we seem to be dangerously near the region of metaphysics, within measurable distance of the Berkleian theory, and liable, if not careful, to fall into space of more than three dimensions. But we are in reality only less materialistic. The enquiries that have led me to this seemingly dangerous position have been chiefly physical and chemical, and those who choose to investigate the sciences with as earnest a wish to effect, or see effected, their unification, may find themselves compelled to adopt a similar conclusion.

It will be some compensation to reflect that a link has been added to the other end of the chain of evolution, and one which from its nature is possibly adapted to make as perfect a connection as we can ever hope to make between the organic and the conscious. It is qualified to lay hold of anything which inherently possesses, or is capable of being made by coercive or inductive power to acquire, a corresponding regular periodic motion whereupon universal attraction and universal force operation is ever dependent, and that link is sympathy—dynamic sympathy of *unit* particles of matter.

I have not contented myself with merely suggesting that dynamic causes are probably sufficient to account for all differences of substances, to which view the ablest chemists recently incline. I think it is *certain*, and have attempted to show why. It follows from what I have said—in conjunction with the knowledge I have assumed you possess, or may find it expedient soon to acquire—that the atoms are the notes of science, the phenomena of the universe their music.

I cannot ask you to concede this until you have disposed of the Newtonian idea of "mass." I therefore give one more illustration before I close, as a type of many.

Take a body which in the sun's light has a certain colour. Examine it in the various portions of the spectrum produced by admitting some of that light into a dark room through a prism. Note the changes of colour, the special influence of certain waves, and that the body itself remains unchanged.

Now take a body which in the earth's field of force has a certain weight. By the scientific use of your imagination weigh it in the various portions of the terrestrial spectrum produced by admitting gravitic force through a prism into a room from which all other force is supposed to be excluded. Note the changes of weight, the special influence of certain waves, and that the body itself remains unchanged.

In the first case you separated the wave motions due to the sun's constituents, in the second case those due to earth's, but in neither case did the quantity of matter alter.

But this second instance is based upon assumption; do not admit it unless you see the facts of science justify it. If true the changes it involves are infinitely serious, startling, and beautiful. Do not hurry; think it over and draw your own conclusions. If mass always varies directly as weight, I have misunderstood Nature, that is all. If it does not, you will have occasion to remember the fact once you realize it in connection with the principles of dynamic sympathy and selective absorption I have endeavoured to impress upon your minds.

Truly the eye sees only that which it brings with it the power of seeing, and the resistance to change is greater in mental than in ordinary motion, and though many have

abundant means of observing this, few perhaps know why it is so.

Hold fast to that which is true, reject that which is not, but remember that the history of science shows that nothing has been more detrimental to its progress, nothing more destructive to its highest interests, and therefore more prejudicial to the welfare of humanity than the servile worship of names, and the attempt to drag *as all-sufficient* into the present and perpetuate into the future the authorities of a dead though venerable past.

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